LOXAHATCHEE RIVER WATER QUALITY AND BIOLOGICAL MONITORING

TASK 13B: FINAL REPORT
SPATIAL AND TEMPORAL DYNAMICS OF SEAGRASS IN THE LOXAHATCHEE RIVER ESTUARY DURING THE PERIOD OCTOBER 2007 – SEPTEMBER 2008

In Partial Fulfillment of Contract SAP #4600001281

For the Period

October 2007 through September 2008

Respectfully Submitted by

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Introduction

Between October 2007 and September 2008, Loxahatchee River District's Wildpine Ecological Laboratory staff monitored seagrass every-other-month (bi-monthly) at four sites located within the Loxahatchee River Estuary and at a reference site in the southern Indian River Lagoon. Monitoring was conducted to characterize spatial and temporal variation in seagrass percent cover and canopy height within the Loxahatchee River estuary. As a valued ecosystem component, seagrasses will be used to assess restoration success following modified freshwater inflows resulting from the Comprehensive Everglades Restoration Project (CERP 2001) and the Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD 2006).

Seagrasses have been identified as a valued ecosystem component because they fulfill key ecological functions in estuaries. For example, they provide food and refuge from predation for numerous economically and ecologically important species (Zieman 1982; Zeiman et al. 1989; Holmquist et al. 1989; Montague and Ley 1993). Seagrasses also are a critically important component of estuarine productivity (Short et al.1993; Fourqurean et al. 2001). Furthermore, seagrasses have been identified as a biological indicator of water quality and ecosystem health (Montague and Ley 1993; Provancha and Scheidt 2000; Lirman and Cropper 2003; Ridler et al. 2006), which suggests that tracking changes in seagrass occurrence and abundance may provide insights into the ecological health of the broader estuary.

Here we use data collected over the past 12 months to evaluate seagrass species composition across the upstream to downstream gradient. Similarly, we characterize spatial and temporal variability among our sampling sites. In addition, we explore correlations between water quality parameters and patterns of seagrass occurrence.

Study Area

The Loxahatchee River estuary encompasses approximately 400 ha and drains a watershed of approximately 700 km^2 located in northeastern Palm Beach County and southeastern Martin County, Florida, USA. Freshwater discharges into the estuary from the North Fork, the Northwest Fork, and the Southwest Fork of the Loxahatchee River. The hydrology of the basin has been substantially altered by flood control efforts since the 1950s. Historically (pre-1950), most surface water runoff reaching the estuary originated in the Loxahatchee and Hungryland Sloughs and flowed gradually to the Northwest Fork. In the 1930s

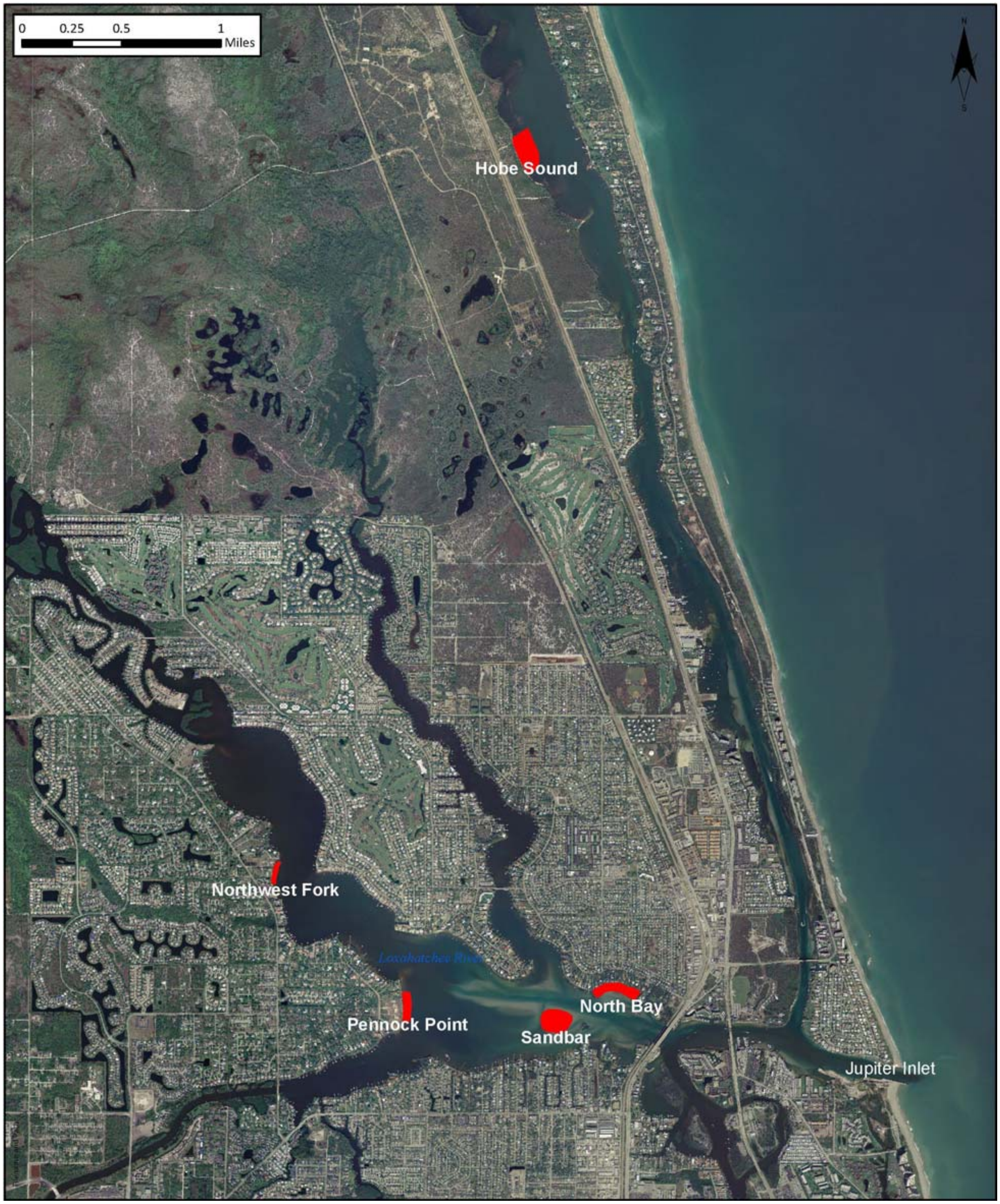

Figure 1. Seagrasses were sampled every other month in the Loxahatchee River at four locations (Northwest Fork, North Bay, Sand Bar, and Pennock Point) and at a reference location in the Indian River Lagoon (Hobe Sound). The red polygons represent the actual size and shape of the seagrass bed monitored at each location.

Lainhart Dam, a small fixed-weir dam, was constructed in the Northwest Fork at river mile 14.5 to reduce “over” drainage of upstream reaches of the Northwest Fork during the dry season. In 1958 a major canal (C-18) and flood control structure (S-46) were constructed to divert flows from the Northwest Fork to the Southwest Fork, which increased the intensity and decreased the duration of storm-related discharge to the estuary. Furthermore, since 1947 Jupiter inlet, the eastern link to the ocean, has been kept permanently open through ongoing dredging projects, which has increased saltwater intrusion into the primarily freshwater Northwest Fork. Ongoing restoration efforts seek to increase base flows into the Northwest Fork, while not compromising the ecological integrity of downstream reaches (i.e., estuary) nor impairing valued ecosystem components of the estuary such as oysters and seagrasses (SFWMD 2006).

Four seagrass beds in the central embayment of the Loxahatchee River Estuary and a reference seagrass bed in the southern Indian River Lagoon and were selected as sample sites based on three primary factors: proximity to the river forks flowing into the estuary, seagrass cover and persistence. This project was established following a four year transect based seagrass monitoring project in the Loxahatchee River, which included four of the five sites assessed in the present study. At each sample site the seagrass bed to be monitored was delineated with a GPS to allow random sampling within the defined seagrass patch over time (Figure 1). Our North Bay (NB) seagrass bed was 5.29 acres (2.14 ha), and was located at river mile 1.5 in the northern most embayment area approximately 500 meters west of the railroad bridge. This site was the most downstream site, and therefore experienced the most stable, marine-like conditions among the four Loxahatchee River sampling sites. North Bay was characterized as a shallow cove seldom more than one meter deep and is protected from the main boating channel by a sandbar located to the south and running the length of the seagrass bed. The shore line was residential and mostly composed of red mangroves with occasional seawalls. Six species of seagrass have been found within this bed. Manatee grass, shoal grass, Johnson’s grass, turtle grass, paddle grass, and star grass were present during the previous transect-based study.

The Sand Bar (SB) seagrass bed was 8.71 acres (3.52 ha), and was located at river mile 1.8 in the central portion of the central embayment; therefore, the site was directly influenced by water flowing in from the inlet and downstream from both the Northwest and Southwest Forks of the Loxahatchee River. The area was a shallow sand bar adjacent to and south of the main channel in the central embayment. Shallowest portions of the sand bar received considerable foot traffic as people recreated on the sand bar. The site is separated from the shore line by a marginal channel. Five species of seagrass have been found within this area. Johnson's grass, shoal grass, paddle grass, manatee grass, and turtle grass were found at this site during the previous study.

Our Pennock Point (PP) seagrass bed was 2.96 acres (1.20 ha), and was located at river mile 2.6 at the far western edge of the central embayment – along the eastern shore of the peninsula created by the Northwest and Southwest forks (Figure 1). This site was directly influenced by water flowing downstream from both the Northwest and Southwest Forks of the Loxahatchee River. The shoreline at this location was predominantly undeveloped residential lined by a continuous seawall with some scattered red mangroves. The seagrass bed at this site is shallow and extends from the sandy shore out fifty meters to a typical depth of 1.5 m. Shoal grass and Johnson's grass were the only two seagrass species recorded at this location during the previous study.

Our Northwest Fork (NWF) seagrass bed was 0.97 acres (0.49 ha), and was located at river mile 3.3 in the Northwest Fork of the Loxahatchee River. This site was the most upstream site, and therefore was most affected by freshwater flowing downstream from the Northwest Fork of the Loxahatchee River. The site was characterized as a slight embayment along the western shore with the shoreline being residential and mostly lined by red mangroves with occasional seawalls. The seagrass bed at this site was approximately 175 meters wide and extended 25 meters out from the sandy shore to a typical depth of 1.4 m. Johnson's grass and shoal grass have been found at this site during earlier assessments (e.g., 2007 mapping), though it was not included in the previous transect-based study.

The reference (HS) seagrass bed was 10.79 acres (4.37 ha), and was located in the southern Indian River Lagoon. This site was an excellent reference site because it was located 8 km north of the Jupiter Inlet and was not affected by freshwaters discharged from the Loxahatchee River watershed; thus, the reference site experienced more stable, marine-like salinity conditions than the Loxahatchee River Estuary. The site was located on the western bank of the Indian River Lagoon adjacent to the sandy shore of a bird sanctuary. Unlike the Sand Bar site, this site received very little public use. The seagrass bed at this site extended approximately 165 meters off shore, and the deep edge of the bed exceeded 1.5 m in depth. During the previous study manatee grass, shoal grass, turtle grass, Johnson's grass, and paddle grass were found at this site.

Materials and Methods

Seagrass beds were monitored bi-monthly (every two months) for the period October 2007 through August 2008. During each sampling event we assessed percent cover for each seagrass species encountered. Divers quantified percent cover of all seagrasses at each site by haphazardly deploying a 1 m^2 quadrat approximately 30 times within each seagrass sampling site. Each 1 m^2 quadrat was subdivided into 25 equilateral 20 cm x 20 cm cells. Seagrass percent cover was assessed by quantifying the number of cells (out of 25) in which each seagrass species occurred. In addition, the number of bare (no seagrass) cells was quantified for each quadrat sampled. These count data (i.e., how many cells had *S. filiforme*) were converted to percent cover data by dividing the number of cells in which the seagrass species occurred by the total number of cells (25). For example, a quadrat in which *S. filiforme* was present in 12 of 25 cells, *H. wrightii* was present in 16 of 25 cells, and 3 cells were bare (i.e., no seagrass present) was recorded as having the following percent cover values: S. filiforme 48%, H. wrightii 64%, and total seagrass cover 88%. Seagrass canopy height was quantified in each quadrat assessed for seagrass percent cover by measuring the average blade length (distance from substrate to blade tip) of shoots of the dominant canopy-forming seagrass species in each quadrat. In order to facilitate spatial analyses, the position of each quadrat was georeferenced.

Concurrent with seagrass data collection, physical and chemical water quality parameters were evaluated and freshwater discharge into the system was recorded. Throughout the study, temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, chlorophyll a, and Photosynthetic Available Radiation (PAR) were recorded bi-monthly at the time of seagrass sampling in the channel adjacent to each seagrass site and at a site in the middle of each seagrass bed. Furthermore, data from RiverKeeper water quality stations 40 and 42 (central embayment), 60 (Northwest Fork), and 25 (Hobe Sound) provide monthly or bi-monthly assessments of nutrients in the vicinity of the seagrass sampling sites. Salinity, temperature, and depth were recorded every 15 min at the NB and PP sites using a Hydrolab Minisonde 4a positioned at seagrass canopy height (~ 25 cm off the bottom). Water quality samples were processed following Standard Methods by the Loxahatchee River District's Wildpine Laboratory, which is certified under the National Environmental Laboratory Accreditation Program. Photosynthetically active radiation (PAR) was assessed by taking 3 replicates of PAR using 3 LI-COR spherical sensors (4 π) simultaneously located at 20 cm, 50 cm, and 100 cm below the water surface. Data were recorded on a LI-COR LI-1400 data logger. Light attenuation coefficient (Kd) was calculated as the slope of natural log transformed PAR values regressed against depth. Following Kemp et al. (2004), the percent of light passing through the water column to seagrasses (PLW) was calculated as PLW = 100 exp [(-Kd)(Z)], where Kd is the light attenuation coefficient and Z is the depth of seagrass growth. Freshwater discharge into the Southwest Fork was recorded continuously at the S-46 structure, while freshwater discharge into the Northwest Fork was recorded continuously at Lainhart Dam. Discharge from the North Fork generally contributes approximately 6% of mean daily flow into the estuary and was not assessed during this period (SFWMD 2006).

Results

The primary purpose of this study was to generate a more comprehensive understanding of spatial and temporal dynamics of seagrass percent cover and canopy height (i.e., measures of seagrass health) within the Loxahatchee River Estuary prior to restoration (augmentation) of freshwater flows to the Northwest Fork of the Loxahatchee River. As such, we assessed seagrass percent cover and canopy height in 786 individual quadrat samples among our five sampling areas during the period October 2007 through September 2008. Seagrasses appeared healthy in the Loxahatchee River, though species composition and percent cover values observed during the present study were below the values observed prior to October 2004 when several major storms adversely impacted seagrasses in the Loxahatchee River Estuary (Ridler et al. 2006).

Percent Cover

Total seagrass percent cover, i.e., one minus the percent cover score for bare substrate, exhibited different patterns among our sampling sites (Figure 2). Percent cover of seagrass was relatively constant at the reference site and Sand Bar. Seagrass cover at Pennock Point exhibited a gradual and continual increase throughout the year. Seagrass cover at North Bay and Northwest Fork sites showed significant reductions during the winter months (i.e., December 2007 and February 2008) and a rapid recovery through the warmer summer months. At present, we do not understand why these striking seasonal patterns were observed at only two of our sampling sites. We look forward to a second year of monitoring using this approach to better understand these apparent seasonal patterns.

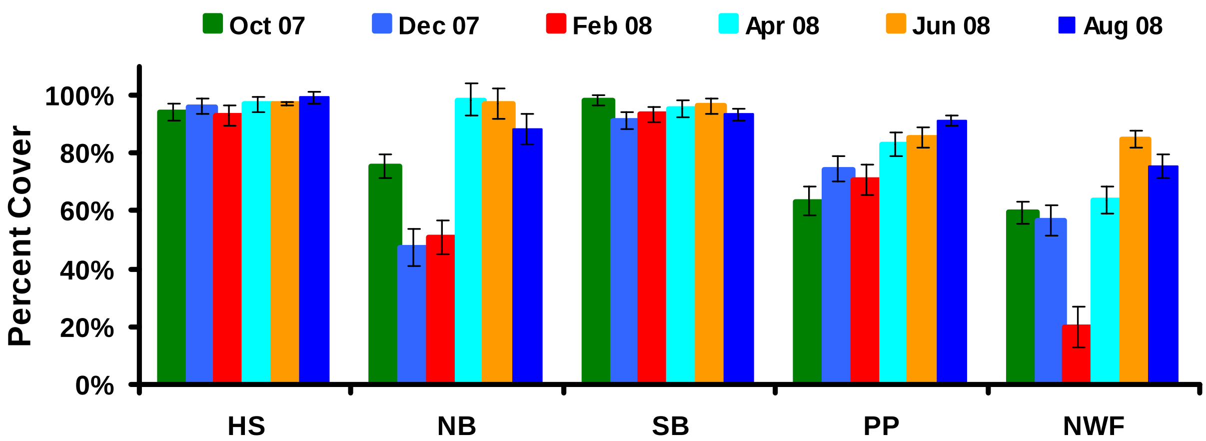

Figure 2. Total seagrass cover showed relatively little variability at some sites (e.g., reference site and Sand Bar) and showed considerable seasonal change at other sites (e.g., North Bay and Northwest Fork). Error bars represent ± 1 Standard Error.

Manatee grass uniformly dominated the reference site (HS) throughout the year; manatee grass covered more than 60% of the area during each sampling event (Figure 3). Shoal grass was the second most abundant species at the reference site, and typically covered 20-40% of the area assessed. Turtle grass, another canopy forming species, occurred in isolated patches at this site, though it was locally abundant in these isolated patches. Sub-canopy species such as Johnson's grass and paddle grass were infrequently encountered, and appeared most commonly along the deep edge of the bed (Appendix A, Figure 6) or in small areas that had been disturbed. It appears that the relatively stable salinity conditions at this site, due to the lack of freshwater inflows, have allowed manatee grass, a canopy-forming, k-selected species sensitive to salinity fluctuations, to uniformly dominate this site through time.

Seagrass cover at North Bay (NB) was indicative of the diversity observed at this site. Johnson's grass, shoal grass, and manatee grass were the dominant species observed at this site (Figure 3). In general, Johnson's grass occurred in the deeper portions of the bed (near shore), shoal grass was more dominant along the southern edge (near the eroding part of the sand bar), and manatee grass was most prevalent in the middle portion of the seagrass bed (Appendix A, Figure 7). Isolated patches of turtle grass were present at this site, but never comprised more than three percent of the seagrass cover. This site had the most stable salinity regime of the Loxahatchee River Estuary sites, which may explain why manatee grass was most abundant among the Loxahatchee River sites. However, manatee grass percent cover at this site continues to lag far below the conditions observed prior to the hurricanes of 2004 (Ridler et al. 2006).

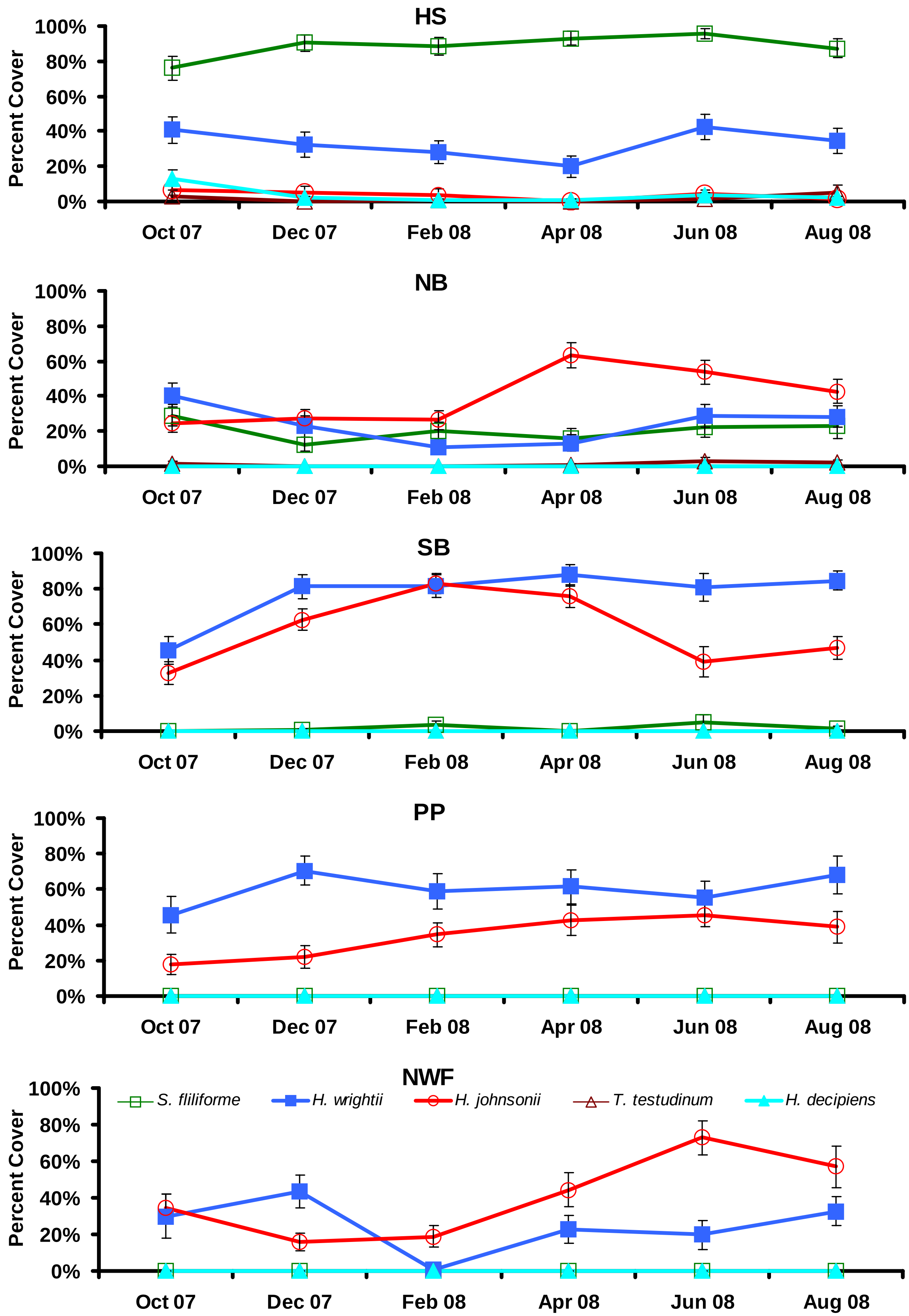

Figure 3. Percent cover data suggest strong differences in seagrass health among Loxahatchee River sites across the upstream-downstream gradient. Error bars represent ± 1 Standard Error.

Shoal grass and Johnson's grass dominated seagrass cover at our Sand Bar site (SB) throughout the year, though Johnson's grass exhibited stronger seasonal declines (Figure 3). In general, this site was characterized by a nearly even mixture of shoal grass and Johnson's grass, though Johnson's grass was most prevalent in some of the deeper portions of the seagrass bed (i.e., the southwest corner) (Appendix A, Figure 8). Manatee grass was present at this site in isolated, sparse patches.

Sampling at our Pennock Point site (PP) revealed shoal grass covered nearly 40% of the site throughout the study (Figure 3), whereas Johnson's grass typically covered 10 to 35% of the assessed seagrass bed. In general, shoal grass was dominant in shallower, near-shore areas and Johnson's grass was most commonly found along the deep edge of the bed (Appendix A, Figure 9). We suggest manatee grass was absent from this site due to the wide fluctuations observed for salinity conditions at this site (see Figure 4).

Seagrass cover was most sparse at our Northwest Fork site (NWF) among all of the sites sampled. At this site, Johnson's grass and shoal grass were the only species encountered, and they generally covered about 60% of the area (Figure 3). Similar to the spatial distribution observed at PP, shoal grass was dominant in shallower, near-shore areas and Johnson's grass was most commonly found at deeper sites (Appendix A, Figure 10). Because of the freshwater flowing down the Northwest Fork of the Loxahatchee River, this site had the highest average water color, lowest light penetration, and lowest average salinity condition, and most variable salinity conditions among the seagrass sites sampled (Figure 4).

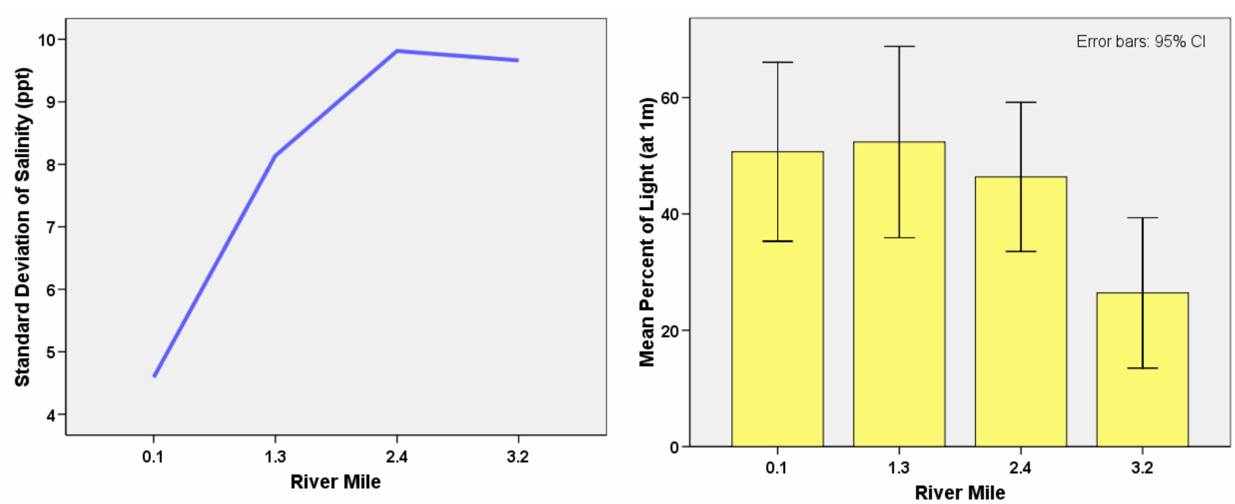

Figure 4. Salinity variability, i.e., seagrass stress, increases as one moves upstream in the Loxahatchee River, while the percent of light reaching seagrass 1 meter deep shows a significant decline at the river mile corresponding to our NWF site. Error bars represent ± 1 Standard Error.

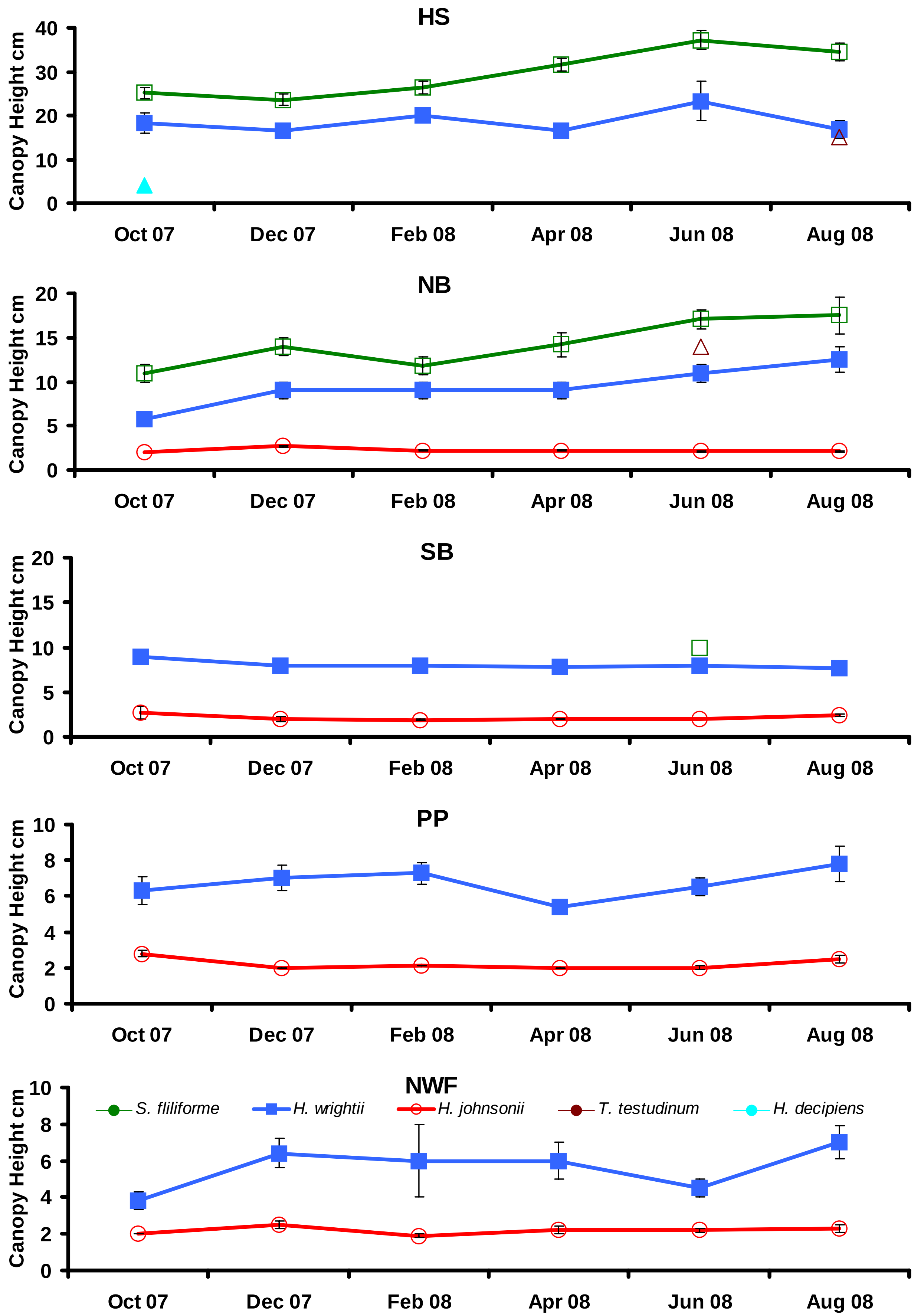

Figure 5. Canopy height data show among-site differences in seagrass bed condition are generally correlated with the upstream-downstream gradient (i.e., note how canopy height of shoal grass varies across sites). Error bars represent ± 1 Standard Error.

Canopy Height

Results from seagrass canopy height, i.e., how tall was the seagrass meadow, provide interesting insight into the relative health of the seagrass beds assessed. Figure 5 shows canopy height varied (1) as a function of the canopy-forming seagrass and (2) as a function of the relative influence of freshwater discharges. Seagrass beds that contained manatee grass consistently had greater observed canopy height values than beds without manatee grass (of course, manatee grass grows taller than shoal grass, which grows taller than Johnson's grass). Seagrass beds experiencing more stable salinity regimes (see Figure 4), i.e., influenced less by freshwater discharges, were more likely to include manatee grass, and therefore to have greater observed canopy height measurements. In addition, canopy height for both manatee grass and shoal grass was negatively correlated with the amount of freshwater influence. For example, maximum canopy height for manatee grass was 37.2, 17.5, 10.0, 0.0 cm for HS, NB, SB, and PP, respectively. Similarly, maximum canopy height for shoal grass was 23.3, 12.5, 9.0, 7.8, and 7.0 cm for HS, NB, SB, PP, and NWF, respectively. Thus, there was a somewhat surprising correlation between river mile (a surrogate for freshwater influence) and canopy height, where canopy height appears to clearly suggest the most healthy seagrass beds occurred at the most downstream sites that were least impacted by freshwater discharges.

Discussion

Ongoing seagrass monitoring in the Loxahatchee River Estuary has provided interesting insights into the ecology and dynamics of seagrasses. During the period October 2007 – September 2008 seagrass in the Loxahatchee River Estuary appeared to be relatively healthy, though percent cover values were below those observed prior to the October 2004 hurricanes. By comparing seagrass conditions in the Loxahatchee River against those of the reference site and across the upstream-downstream gradient in the Loxahatchee River we were better able to understand the impacts freshwater discharges had on seagrass conditions. Finally, the methods employed in the present study are synonymous with methods being employed throughout the other estuaries in South Florida as part of CERP Monitoring and Assessment Program. Therefore, we expect these results, when combined with results from other systems, will provide a comprehensive understanding of seagrass dynamics across all of the South Florida estuaries.

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Appendix A. Stacked bar graphs show species-specific seagrass percent cover data within each sampling site across the entire sampling period (Oct. 2007 – Sept. 2008). **Figure 6.** The image below shows the dominance of manatee grass and shoal grass at the reference site (HS). Paddle and Johnson's grass occurred primarily in the deepest areas. Stacked bars represent the relative percent cover for each species for each individual sample point assessed during this period.

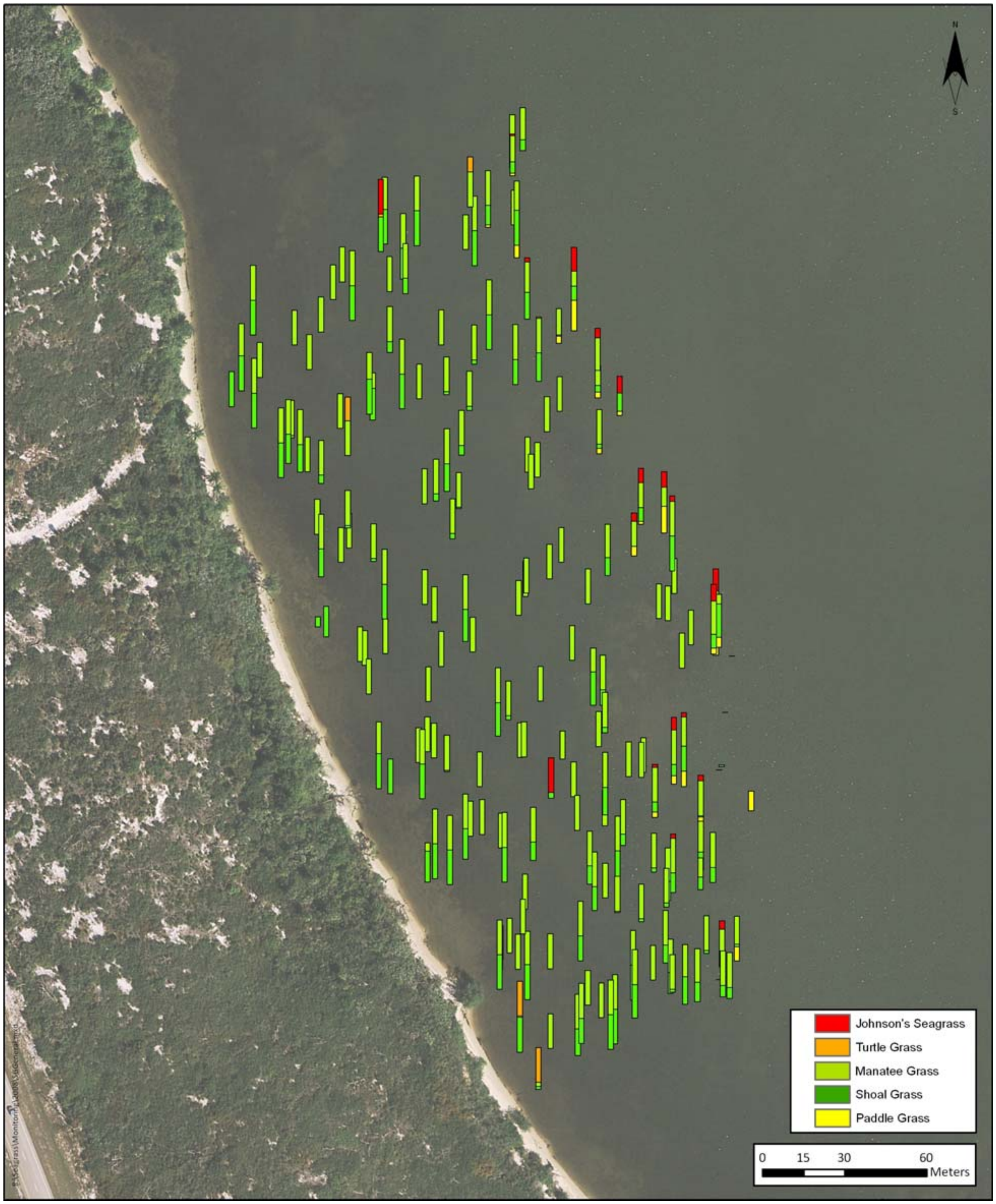


Figure 7. The image below shows the diversity of seagrass at the North Bay site (NB). Also, you can see the large sandbar that borders the seagrass bed to the south. Stacked bars represent the relative percent cover for each species for each individual sample point assessed during this period.

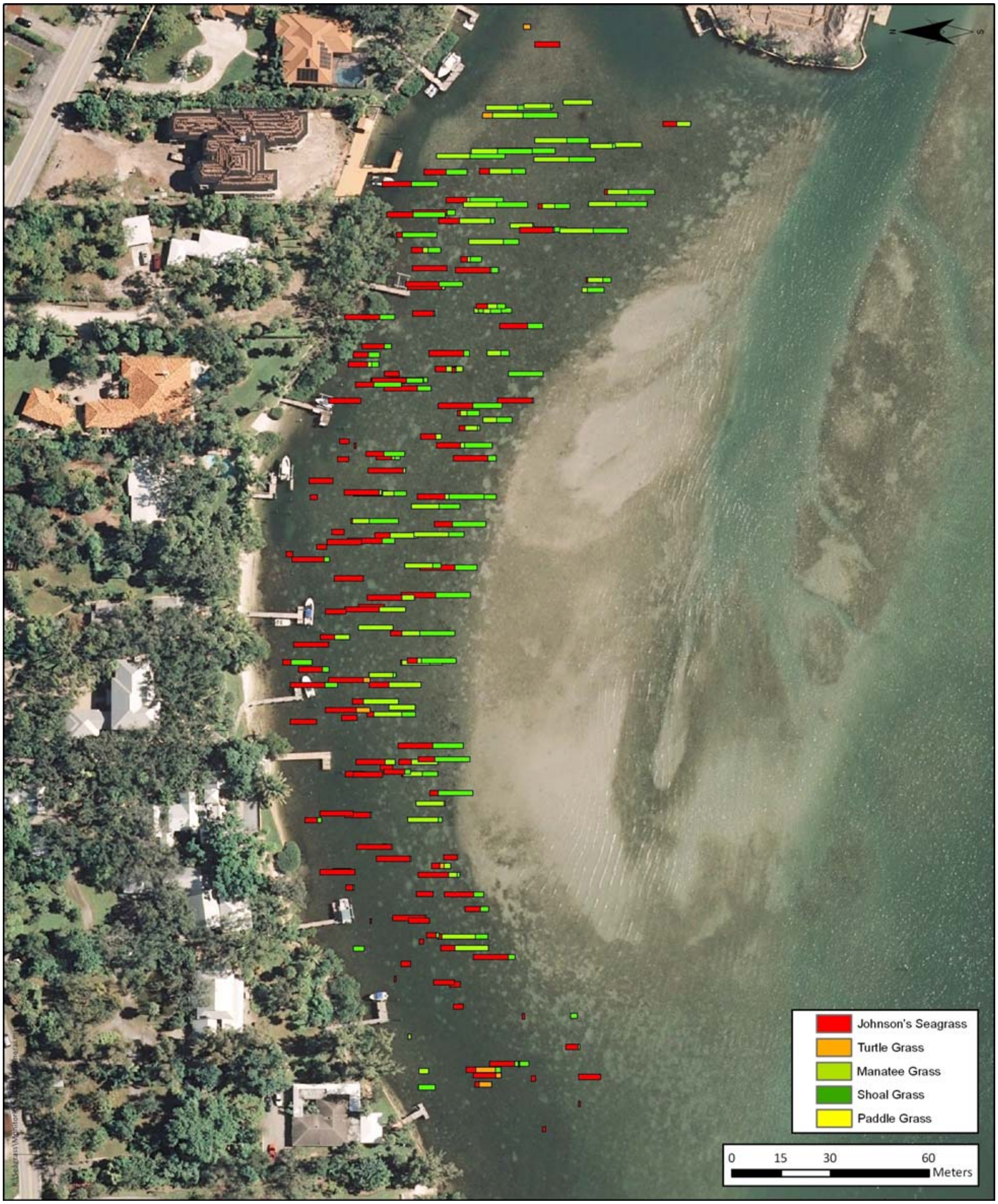


Figure 8. The image below shows the dominance of shoal grass and Johnson's grass and the few isolated patches of manatee grass at the Sand Bar site (SB). Also, you can see the seagrass bed in the context of the bathymetry at the sandbar. Stacked bars represent the relative percent cover for each species for each individual sample point assessed during this period.

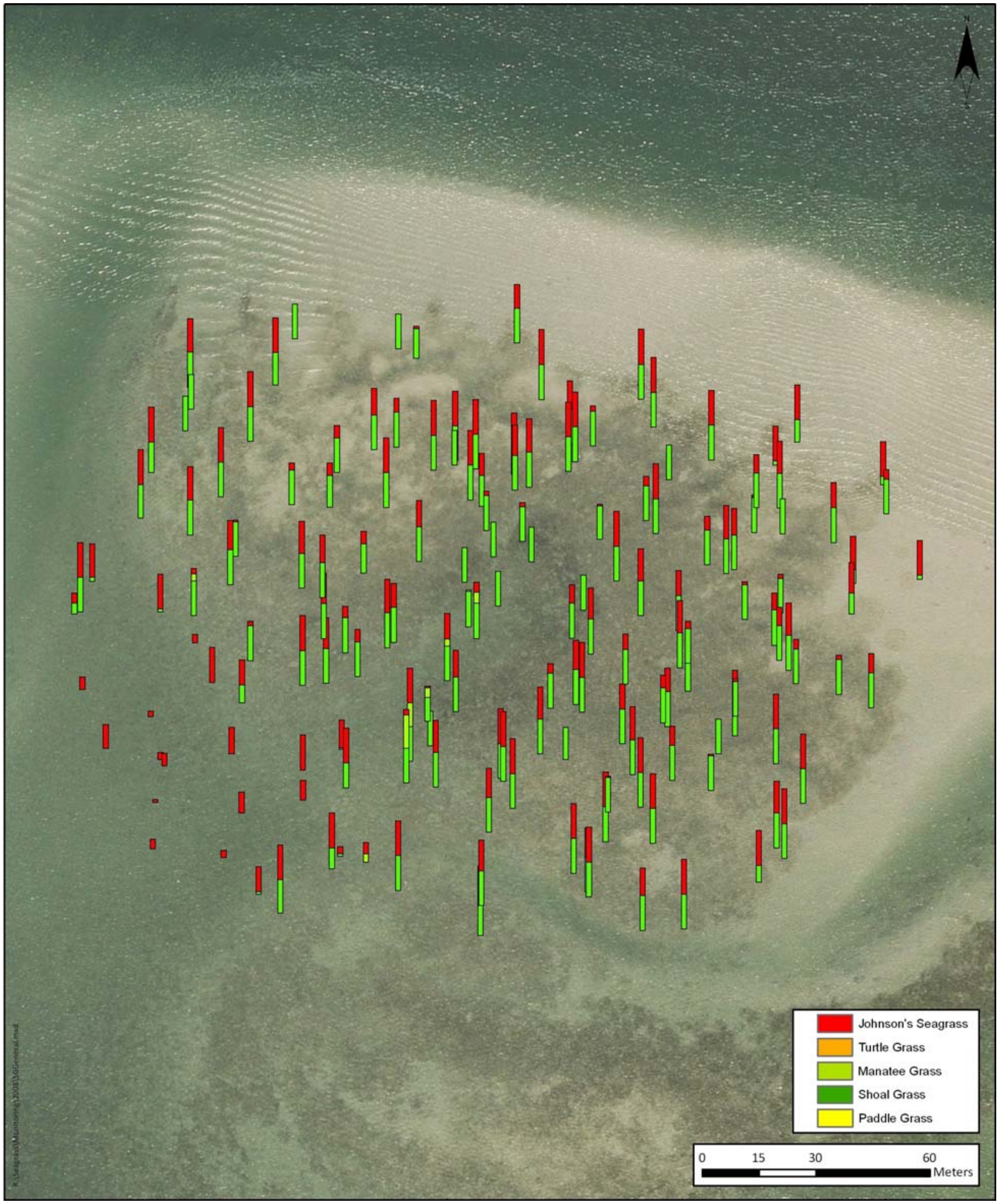


Figure 9. The image below shows the relative stratification between shoal grass (near shore, shallow) and Johnson's grass (off shore, deeper) at the Pennock Point site (PP). Stacked bars represent the relative percent cover for each species for each individual sample point assessed during this period.

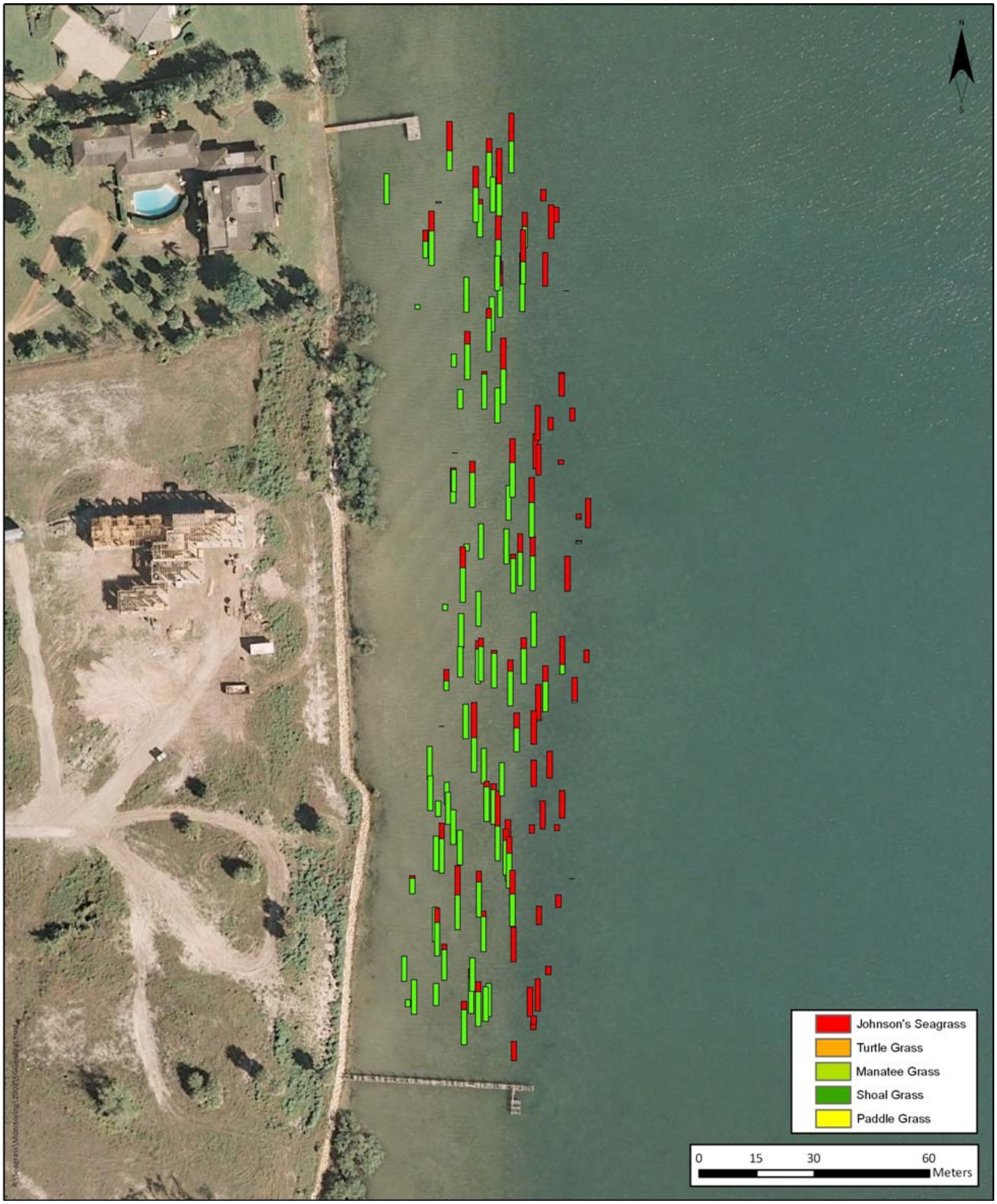
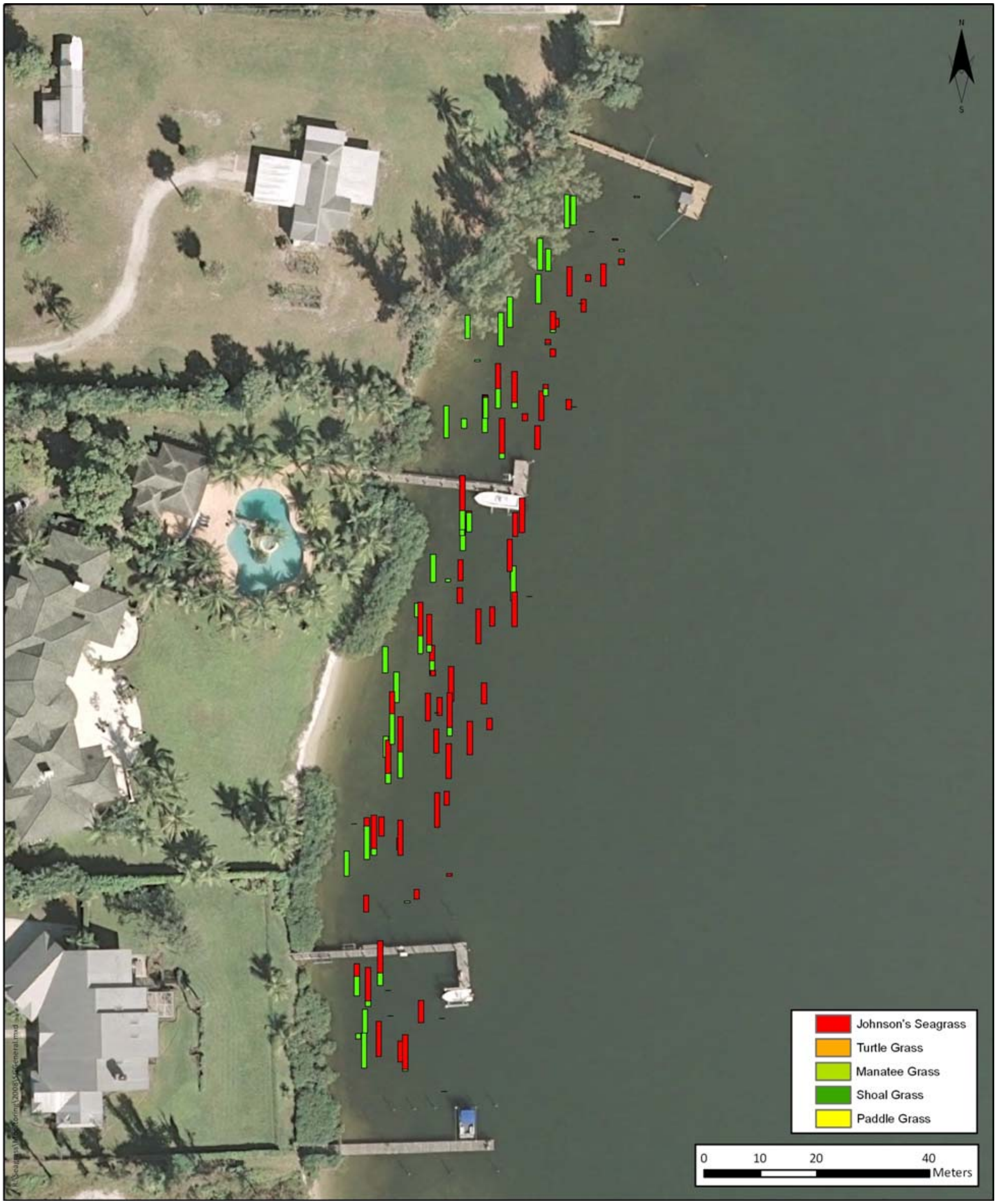


Figure 10. The image below shows the dominance of Johnson's grass at the Northwest Fork site (NWF). At these upstream locations, where water clarity and light attenuation is generally lower, shoal grass was generally limited to a narrow, near-shore band. Stacked bars represent the relative percent cover for each species for each individual sample point assessed during this period.



Appendix B. A compact disk containing the full dataset for the October 2007 through September 2008 sampling period is available upon request by contacting Bud Howard (telephone: 561-747-5700 x108; email: bud@loxahatcheeriver.org) or Lorene Bachman (telephone: 561-747-5700 x143; email: wildpine@loxahatcheeriver.org).